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(54) Amalgam suitable for use in a low mercury vapor pressure discharge lamp.

(57) An amalgam has a base metal including bismuth in an amount selected from the range between about 45 wt% and 65 wt%, and lead in an amount selected from the range between about 35 wt% and 55 wt%. The amalgam also includes mercury the amount of which is selected from the range between about 1 wt% and 12 wt% of the total amount of the amalgam. Such amalgam is sealed in a low mercury vapor pressure discharge lamp which operated at a medium tube surface temperature to achieve a stable mercury vapor pressure over an extended amalgam temperature range.

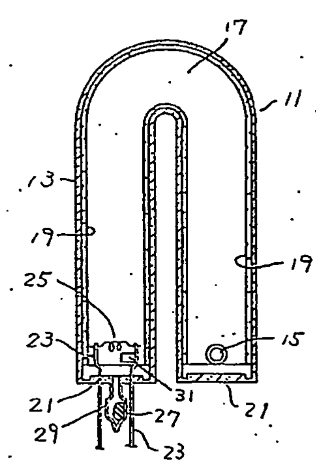


FIG. 5

EP 0 327 346 A2

Description

This invention relates to an amalgam suitable for sealing in the tube of a mercury vapor discharge lamp to control the mercury vapor pressure in the tube within a prescribed range during the operation. The invention also relates to a low mecury vapor pressure discharge lamp, using the above-described amalgam, which operates under a medium tube surface temperature, e.g., 60°C or 70°C.

In general, a low mercury vapor pressure discharge lamp, e.g. straight type fluorescent lamp, is provided with pure mecury. The mercury vapor pressure in the tube is maintained at substantially 6.0×10^{-3} torr when the tube surface temperature is 40°C. Under such a mercury vapor pressure described above, the fluorescent lamp can operate at its desirable characteristics.

In recent years, small sized fluorescent lamps, called ball-type fluorescent lamps, have been developed. In one of the ball-type fluorescent lamps, (hereinafter referred to as a high temperature ball-type lamp), the tube is bent and is housed in a small sized hermetic globe together with an electrical ballast. In this type of lamp, since heat radiated from the tube and the ballast does not readily escape from the globe, the tube surface temperature of the lamp increases above 90°C during the operation. In this case, the luminous flux of the lamp decreases if the mercury vapor pressure in the tube increases excessively. To control the mercury vapor pressure within a prescribed range, an amalgam, such as, e.g., bismuth (Bi) - indium (In) amalgam, etc., is sealed in the tube. Such amalgam controls the mercury vapor pressure in the tube at a desirable value when the tube surface temperature is about 90°C.

On the other hand, another ball-type fluorescent lamp, in which the ballast is attached to the outside of the globe, has also been developed as a low mercury vapor pressure discharge lamp. In this type of lamp, (hereafter referred to as a low temperature ball-type lamp), a small fluorescent lamp, which has a U-shaped discharge pass or an H-shaped discharge pass and operates under a high wall loading above 500 W/m^2, is used.

In such a low mercury vapor pressure discharge lamp described above, the tube surface temperature is low, as compared with the above-described high temperature ball-type fluorescent lamp in which the amalgam is sealed. However, the tube surface temperature of the above-described low temperature ball-type lamp is relatively high, as compared with the conventional straight-type fluorescent lamp in which pure mercury is sealed. In this case, a desirable luminous flux of the low temperature ball-type lamp is not achieved, even if the above-described bismuth-indium amalgam is sealed in the tube to control the mercury vapor pressure. This is because the tube surface temperature of the low temperature ball-typ lamp is low, as described above. Therefore, such amalgams described above do not operate efficiently. In this case also, if pure mercury is used, rather than the above-described amalgams, the mercury vapor pressure in the low temperature ball-type lamp increases to an excessive level and, thus, a desirable luminous flux also is not achieved.

Accordingly, it is an object of the present invention to effectively control the mercury vapor pressure in a low mercury vapor pressure discharge lamp which operates under a relatively low or medium range tube surface temperature.

According to one aspect of the present invention, an amalgam comprises a base metal including bismuth in an amount selected from the range between about 45 wt% and 65 wt%, and lead in an amount selected from the range between about 35 wt% and 55 wt%; and mercury the amount of which is selected from the range between about 1 wt% and 12 wt% of the total amount of the amalgam.

The base metal may include lead in an amount selected from the range between about 30 wt% and 55 wt%, instead of the range between 35 wt% and 55 wt%, and indium in an amount selected from the range between zero wt% and 10 wt%.

According to a second aspect of the present invention, a low mercury vapor pressure discharge lamp comprises a light permeable sealed tube having means for establishing an electrical discharge therein, said tube containing a quantity of metal vapor and an amalgam as claimed in claim 1 or 2.

These and other objects and advantages of this invention will become more apparent and more readily appreciated from the following detailed description of the presently preferred exemplary embodiments of the invention, taken in conjunction with the accompanying drawings, wherein like reference numerals throughout the various figures denote like structure elements and wherein:

FIGURE 1 is a graph illustrating changes in the mercury vapor pressure of various amalgam samples including the present invention, pure mercury and a conventional amalgam when the amalgam or mercury temperature is changed;

FIGURE 2 is a ternary composition diagram illustrating the composition ratio among bismuth, lead and indium for the base metal of the invention;

FIGURE 3 is a graph illustrating changes in the mercury vapor pressure of an amalgam of another embodiment, the conventional amalgam and pure mercury when the amalgam or mercury temperature is changed;

FIGURE 4 is a side view illustrating a double U-shaped fluorescent lamp wherein the amalgam of the first or the second embodiment is sealed;

FIGURE 5 is a cross sectional view taken on line V-V of FIGURE 4;

FIGURE 6 is a graph illustrating changes in the luminous flux of the double U-shaped fluorescent lamp of FIGURE 4, and a conven-

tional U-shaped fluorescent lamp wherein either pure mercury or the conventional amalgam is s aled; and

FIGURE 7 is a cross sectional view illustrating one of the ends of a straight-type fluorescent lamp.

A first embodiment of the present invention will be described by referring to FIGURE 1. Samples of an amalgam including bismuth (Bi), lead (Pb) and mercury (Hg) with varying compositions were tested. The transition of the mercury vapor pressure of each sample was observed by varying the temperature of the samples. Five amalgam samples were made by varying an amount of mercury added to a base metal, which included 56.6 wt% bismuth and 43.5 wt% lead. The first amalgam sample (T0.5) included 0.5 wt% mercury, taking the gloss weight of the amalgam as 100. The second amalgam sample (T1.0) also included 1.0 wt% mercury and the third amalgam sample (T5) included 5.0 wt% mercury The fourth amalgam sample (T12) included 12.0 wt% mercury, and the fifth amalgam sample (T17) includes 17.0 wt% mercury. Changes in the mercury vapor pressure of each amalgam sample were compared with those of pure mercury and a conventional amalgam, including 64.3 wt% bismuth, 31.7 wt% indium and 4.0 wt% mercury. FIGURE 1 shows the changes of the mercury vapor pressure for each amalgam sample. The curved lines T17, T12, T1 and T0.5 indicate the transition of the mercury vapor pressure of the above-described five amalgam samples, respectively. The numeral suffix of each reference symbol T17, T12, T1 and T0.5 denotes the amount of mercury added to each base metal of the above-described five amalgam samples. The curved line H indicates the transition of the mercury vapor pressure of the pure mercury, and the curved line R indicates the transition of the mercury vapor pressure of the bismuth-indium amalgam (conventional amalgam).

As can be seen in FIGURE 1, the amalgam including 17 wt% mercury has an extremely narrow temperature stable range and a high mercury vapor pressure, as indicated by curved line T17. Thus, the luminous flux decreases when the above-described amalgam including 17 wt% mercury is used in a lamp which operates under a relatively low bulb surface temperature, e.g., 60° C or 70° C. On the contrary, the amalgam including 12 wt% mercury, the amalgam including 5 wt% mercury, and the amalgam including 1 wt% mercury all have a desirable temperature stable range, as indicated by each curved line T12, T5, T1. Furthermore, a stable temperature of the amalgarn including bismuth-lead-mercury is achieved when the amount of mercury added to the above-described amalgam is small.

Consideration of the amount of bismuth and the amount of lead included in the base metal of the amalgam may be made by referring to the bismuth-lead-indium ternary composition diagram shown in FIGURE 2. In FIGURE 2, the line of zero indium indicates only the two components of bismuth and lead. In general, an alloy of bismuth and lead is called a eutectic alloy, and the composition ratio (wt%) b twe n bismuth and lead at the utectic point is 56.3 : 43.5. Several samples were made by varying the composition ratio of bismuth and lead. It was observed that the samples of th above-described composition ratio or a composition ratio close to the above-described composition ratio were suitable. Based on the result of the experiment, the composition of the base metal was determined such that it includes 45 wt% to 65 wt% bismuth and 35 wt% to 55 wt% lead. The amalgam is made by adding 1.0 wt% to 12 wt% mercury to the base metal as compared to the total amount of the amalgam.

A second embodiment of the present invention will now be described with reference to FIGURE 3. In the second embodiment, the amalgam includes bismuth (Bi), lead (Pb), indium (In), the mercury (Hg). In general, the mercury vapor pressure of an amalgam is reduced by adding indium to the amalgam, and is controlled by the amount of the indium added to the amalgam. The mercury vapor pressure of an amalgam sample including 52 wt% bismuth, 42 wt% lead, 3 wt% indium and 3 wt% mercury was measured at varying temperatures. FIGURE 3 shows the result of the experiment. For the purpose of the comparison, FIGURE 3 also shows changes in the mercury vapor pressure of pure mercury and a conventional amalgam including 64.3 wt% bismuth, 31.7 wt% indium and 4.0 wt% mercury. In FIGURE 3, line H indicates changes in the mercury vapor pressure of the pure mercury, and curved line T indicates changes in the mercury vapor pressure of the amalgam sample of the second embodiment. Curved line R indicates changes in the mercury vapor pressure of the conventional amalgam.

As can be seen in Figure 3, the mercury vapor pressure of the second embodiment varies between that of the pure mercury and the conventional amalgam. The amalgam sample of the second embodiment shows a mercury vapor pressure change close to that of the pure mercury on the lower temperature side and also shows a mercury vapor pressure change close to that of the conventional amalgam on the upper temperature side. Thus, the amalgam sample of the second embodiment has a desirable mercury vapor pressure within a relatively wide temperature range, as compared with the pure mercury and the conventional amalgam.

In accordance with the ternary composition diagram shown in FIGURE 2, the weight ratio of three components, i.e., bismuth, lead and indium, each of which is a component of the base metal of the amalgam sample of the second embodiment can be considered. The mercury vapor pressure of an amalgam sample was measured by varying the composition ratio between the base metal and mercury of the amalgam sample. Changes in the mercury vapor pressure of the amalgam sample close to the curve T shown in FIGURE 3 were observed when the base metal of the amalgam sample included 45 wt% to 65 wt% bismuth, 30 wt% to 55 wt% lead and zero wt% to 10 wt% indium, and the amalgam included 1 wt% to 12 wt% mercury. The above-described composition range of bismuth, lead and indium in the base metal is indicated by the meshed area in FIGURE 2. In particularly, if the

amount of bismuth increases abov th above-described range, a substantially flat mercury vapor pressure range shifts toward an upper mercury vapor pressure side, e.g., 1 x 10^{-1} torr. On the contrary, if the amount of bismuth decreases below the above-described range, the mercury vapor pressure extremely decreases when the temperature is low, and thus, the low temperature portion of curve T shown in FIGURE 3 approaches that of the conventional amalgam. If the amount of indium increases above 10 wt%, curve T shown in FIGURE 3 shifts toward the lower mercury vapor pressure side. Furthermore, as the amount of mercury increases above the above-described range, the range in which the mercury vapor pressure is stable becomes narrow and close to curve H shown in FIGURE 3. If the amount of mercury is excessively small, a shortage of mercury would occur because of the consumption of mercury during the operation.

As shown in FIGURES 4 and 5, the amalgam of the first embodiment is sealed in a double U-shaped fluorescent lamp. Double U-shaped fluorescent lamp 11 includes two U-shaped glass tubes 13 and 14 which are connected by a connecting tube 15. A convolute discharge pass 17 is formed in tubes 13 and 14. A fluorescent film 19 is formed on the inner surface of each U-shaped glass tube 13, 14. An end portion of each U-shaped glass tube 13, 14 is sealed by a stem 21. A pair of lead wires 23, 23 extend into the inside of glass tube 13 through one of the stems 21, and a coiled filament 25 is fixed between lead wires 23 and 23. A main amalgam 27 is sealed in an exhausting tube 29 outwardly extending from stem 21 into which the pair of lead wires 23, 23 extends. An auxiliary amalgam 31 is fixed to one of the lead wires 23. Auxiliary amalgam 31 is plate shaped molybdenum or stainless steel which is coated with indium. Such plate shaped molybdenum or stainless steel is amalgamated before or after being sealed in the bulb. An amalgam, including 52.2 wt% bismuth, 41.8 wt% lead and 4 wt% mercury is used as the main amalgam. Since the construction of the other U-shaped glass tube 14 is the same as that of U-shaped glass tube 13, the same numerals are applied to similar portions of U-shaped glass tube 14, and therefore, the description thereof is not repeated. The above-described fluorescent lamp 11 also includes an outer globe (not shown) in which glass tubes 13 and 14 are located. A ballast (not shown) is attached to the outside of the globe. However, the ballast may be assembled with lamp 11 if the globe is not used. The above-described double U-shaped fluorescent lamp 11 has a 27 W rating, and operates at a high wall loading above 500 W/m^2, e.g., 700 W/m^2.

The operation of the above-described lamp will be described hereafter. When each coiled filament 25 in tubes 13 and 14 is energized, auxiliary amalgam 31 is dissolved by heat generated by coiled filament 25 and mercury vapor is released from auxiliary amalgam 31. At this time, mercury in main amalgam 27 does not evaporate because of the low temperature of exhausting tube 29. Discharge occurs betw en coiled filaments 25 when a starting voltage is applied to coiled filaments 25. Sinc exhausting tube 29 is heated by the discharge, main amalgam 27 also is heated and mercury in main amalgam evaporates. As a result, the mercury vapor pressure in bulbs 13 and 14 rapidly increases and the discharge between coiled filaments 25 becomes stable. After main amalgam 27 is activated, the mercury vapor pressure in bulbs 13 and 14 chiefly depends on the temperature of main amalgam 27. When coiled filaments 25 in tubes 13 and 14 are deenergized, the temperatures of main amalgam 27 and auxiliary amalgam 31 gradually decrease. At first, since auxiliary amalgam 31 is coated with indium, a part of the vapored mercury is absorbed by auxiliary amalgam 31 and is amalgamated. Then, the remaining vapored mercury is also absorbed by main amalgam 27 and is amalgamated.

In the above-described lamp, since four straight tube portions of double U-shaped fluorescent lamp 11 are closely arranged in parallel, the bulb surface temperature of each straight portion increases similar to that of the above-described conventional ball-type fluorescent lamp (high temperature ball-type lamp), i.e., 90° C. However, in this U-shaped fluorescent lamp, since the amalgam of the invention is used as main amalgam 27, the mercury vapor pressure in U-shaped glass tubes 13 and 14 is controlled at a desirable range even though main amalgam 27 is heated to a relatively high temperature. Using a double U-shaped fluorescent lamp 11, a desirable luminous flux was obtained even when the temperature of main amalgam 27 was varied within a relatively wide range, i. e., between 40° C and 105°C, as compared with a lamp which uses the conventional amalgam. A suitable temperature of the conventional amalgam exists only at a relatively high temperature side.

The amalgam of the second embodiment was sealed in the double U-shaped fluorescent lamp shown in FIGURES 4 and 5, as a main amalgam, instead of the amalgam of the first embodiment. An experiment was carried out by using an amalgam sample including 50 wt% bismuth, 45 wt% lead, 2 wt% indium and 3 wt% mercury. In the experiment, the relationship between the amalgam temperature and the relative luminous flux of the double U-shaped fluorescent lamp was observed. FIGURE 6 shows the result of the experiment. In FIGURE 6, curve Ta indicates changes in the luminous flux of the double U-shaped fluorescent lamp wherein the above-described amalgam sample is sealed when the amalgam temperature is changed. For the purpose of the comparison, curve Ra indicates changes in the luminous flux of a double U-shaped fluorescent lamp wherein the conventional amalgam is sealed, and curve Ha indicates changes in the luminous flux of a double U-shaped fluorescent lamp wherein pure mercury is sealed.

As can be seen in FIGURE 6, the luminous flux is greatly improved at the lower temperature side, as compar d with the lamp in which th conventional amalgam is sealed. Thus, a stable luminous flux is achieved over an extended temperature range between 40° C and 110° C.

In the above-described lamps, the amalgam of

either the first or the second embodiment is used in the double U-shaped fluorescent lamp which operates at a high wall loading above 500 W/m^2. However, such amalgam may be used in a double U-shaped fluorescent lamp which operates at a relatively low wall loading below 500 W/m^2 if the temperature around the lamp is high. Furthermore, in those lamps, the amalgam of the first or the second embodiment is sealed in the double U-shaped fluorescent lamp. However, the amalgam of the first or the second embodiment may be sealed in a straight-type fluorescent lamp, as shown in FIGURE 7. Similar effects can also be obtained in the straight-type fluorescent lamp. In FIGURE 7, the same numerals are applied to the construction similar to the double U-shaped fluorescent lamp shown in FIGURE 4, and therefore, the description thereof is not repeated.

In summary, it will be seen that the present invention overcomes the disadvantage of the prior art and provides an improved amalgam and a low mercury vapor pressure discharge lamp in which an extended stable mercury vapor pressure is achieved over a wide amalgam temperature range, as compared with a low mercury vapor pressure discharge lamp in which the conventional amalgam or pure mercury is sealed.

Many changes and modifications in the above-described embodiments can be carried out without departing from the scope of the present invention. Therefore, the appended claims should be construed to include all such modifications.

Claims

1. An amalgam comprising a base metal including bismuth in an amount selected from the range between about 45 wt% and 65 wt%, and lead in an amount selected from the range between about 35 wt% and 55 wt%; and mercury the amount of which is selected from the range between about 1 wt% and 12 wt% of the total amount of the amalgam.

2. An amalgam as claimed in claim 1, in which the lead content of the base metal is selected from the range between about 30 wt% and 55 wt% and indium is present in an amount selected from the range between zero wt% and 10 wt%.

3. A low mercury vapor pressure discharge lamp comprising a light permeable sealed tube having means for establishing an electrical discharge therein, said tube containing a quantity of metal vapor and an amalgam as claimed in claim 1 or 2.

4. A discharge lamp as claimed in claim 3, wherein an auxiliary amalgam is present in the tube.

5. A discharge lamp as claimed in claim 4, wherein the amalgam and the auxiliary amalgam are positioned in the tube such that, in use, the auxiliary amalgam is at a higher temperature than the amalgam.

6. A discharg lamp as claimed in claim 5, in which the means for establishing an electrical discharge includes a pair of spaced apart electrode structures and the auxiliary amalgam is mounted on one of the structures.

7. A discharge lamp as claimed in claim 6, in which the auxiliary amalgam includes molybdenum or stainless steel having a coating of indium.

8. A discharge lamp as claimed in any one of the claims 3 to 7, in which the light permeable tube is contained within a light permeable globe.

9. A discharge lamp as claimed in claim 8, in which an electrical ballast is contained within the globe.

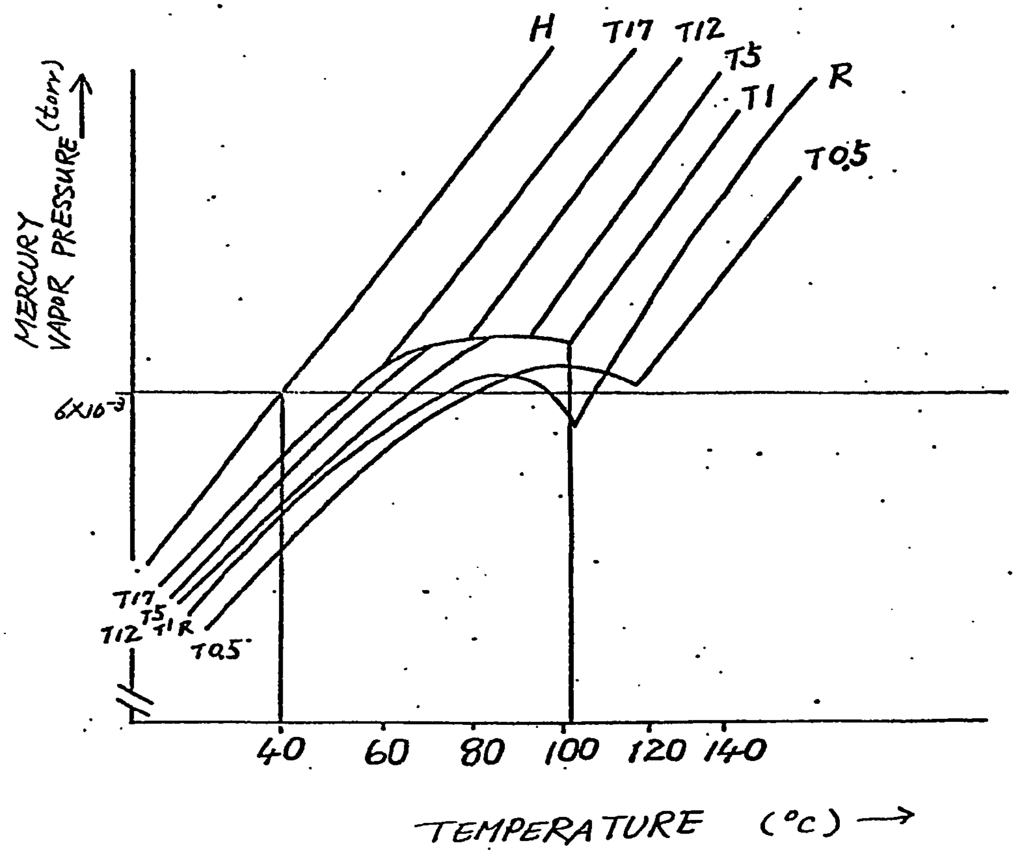

H
T17
T12
T5
T1
R
T0.5
MERCURY VAPOR PRESSURE (torr)
6X10⁻³
T17
T12
T5
T1
R
T0.5
40
60
80
100
120
140
TEMPERATURE (°C)

FIG. 1

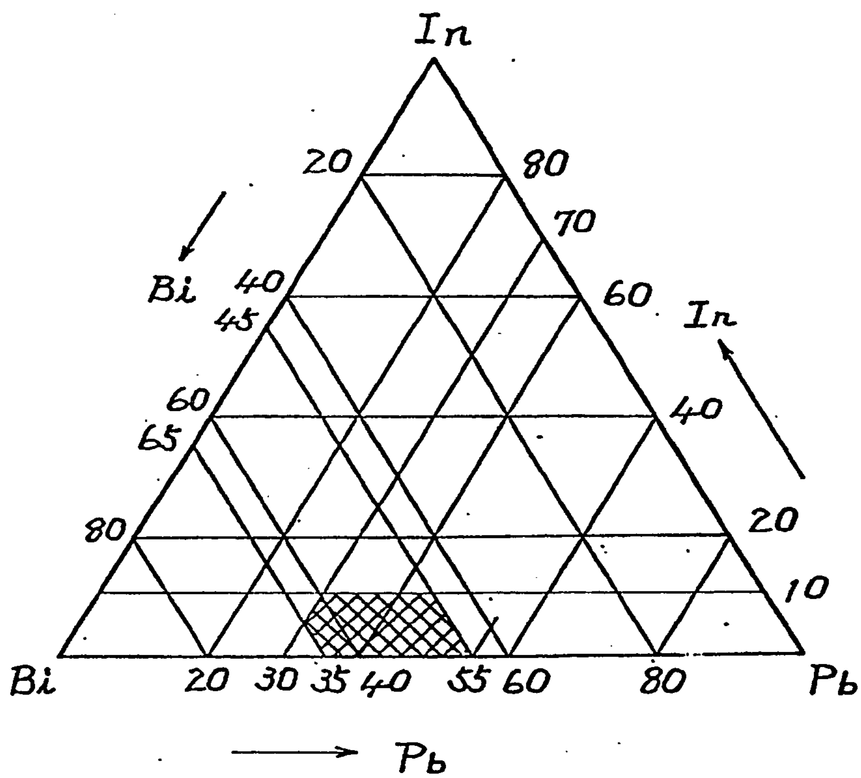
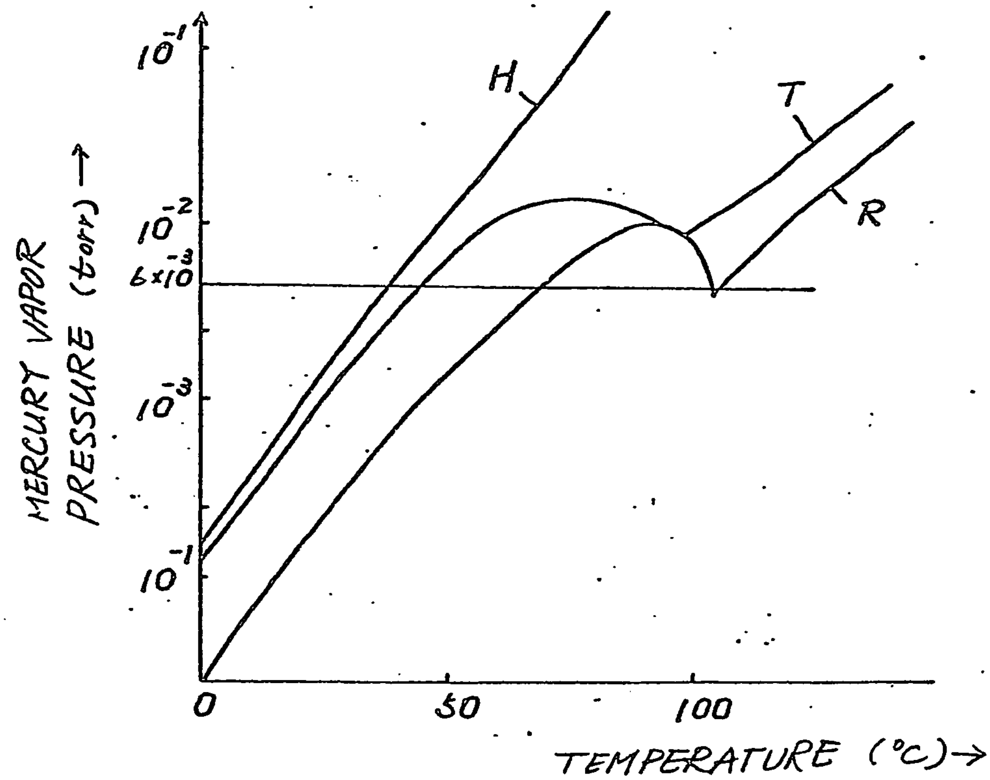
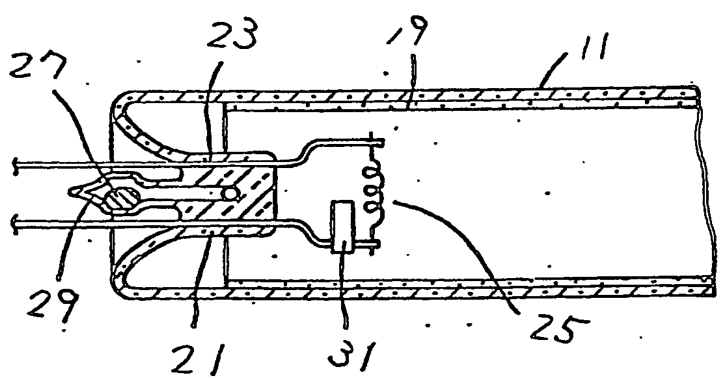

In
20
80
70
Bi
40
45
60
In
60
65
40
80
20
10
Bi
20
30
35
40
55
60
80
Pb
Pb

FIG. 2



MERCURY VAPOR PRESSURE (torr) →
10^{-1}
10^{-2}
6×10^{-3}
10^{-3}
10^{-1}
0
50
100
TEMPERATURE (°C) →
H
T
R

FIG. 3



27
23
19
11
29
21
31
25

FIG. 7

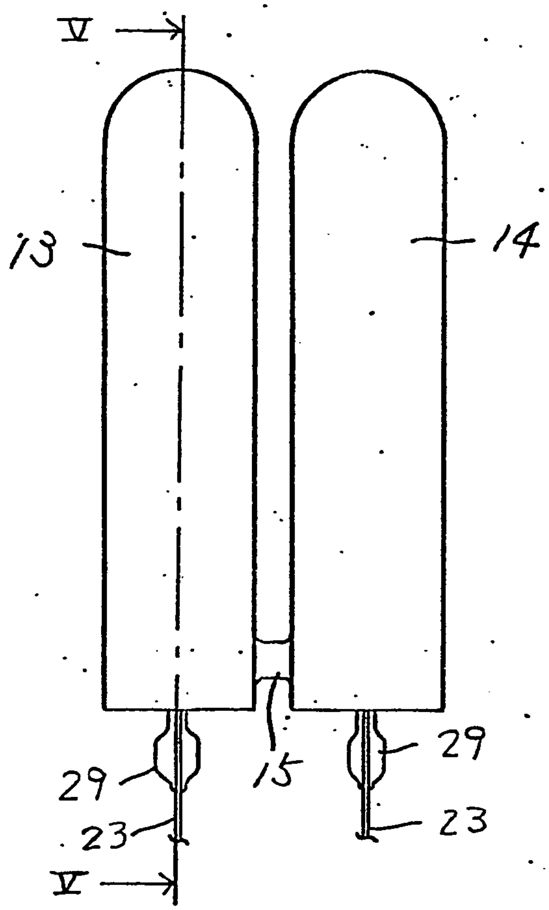


FIG. 4

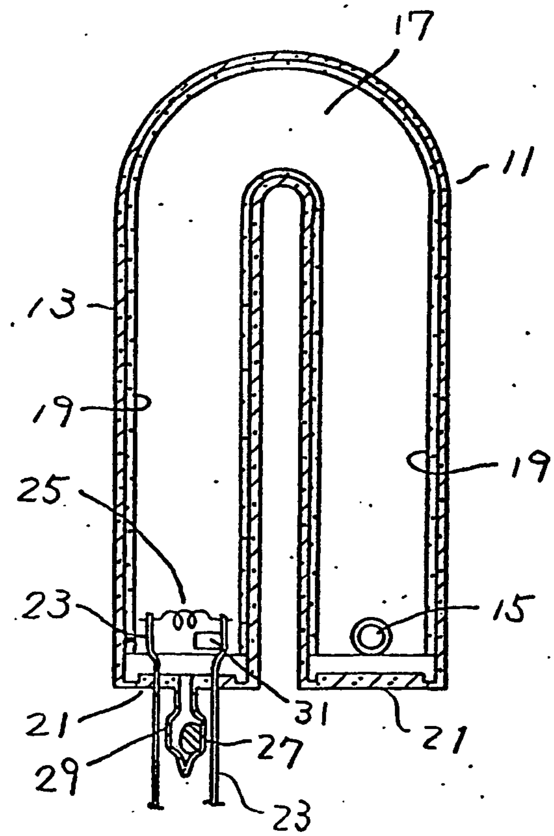


FIG. 5

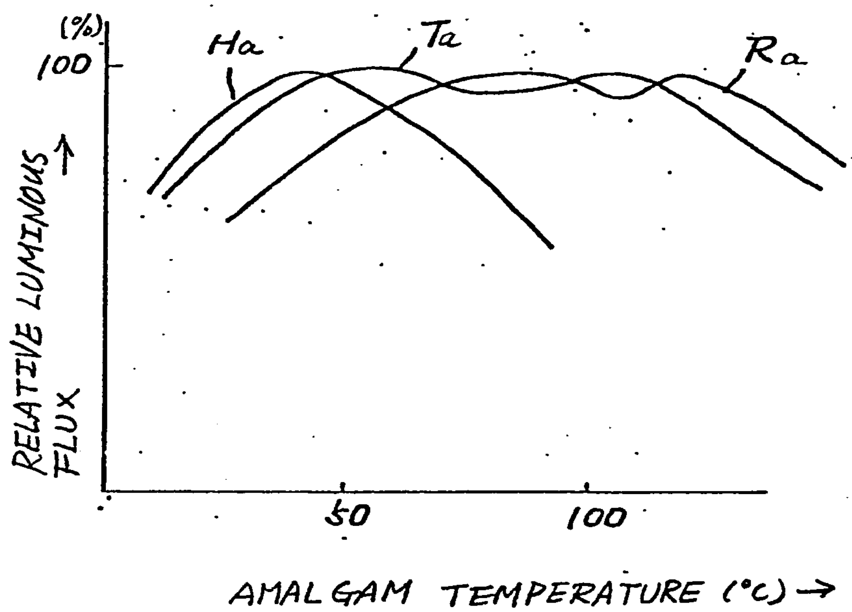

(%)
100
Ha
Ta
Ra
RELATIVE LUMINOUS FLUX
50
100
AMALGAM TEMPERATURE (°C)

FIG. 6

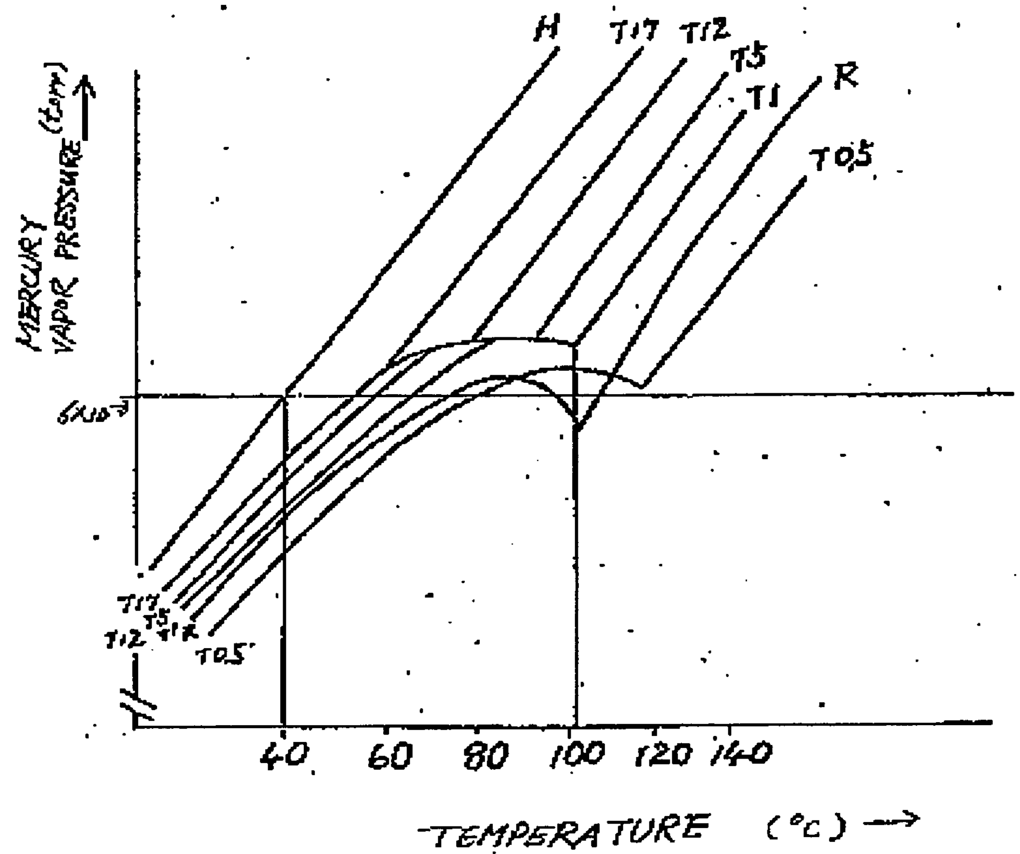

H
T17
T12
T5
T1
R
T0.5
MERCURY VAPOR PRESSURE (torr)
6x10⁻³
T17
T12
T5
T1
T0.5
40
60
80
100
120
140
TEMPERATURE (°C)

FIG. 1

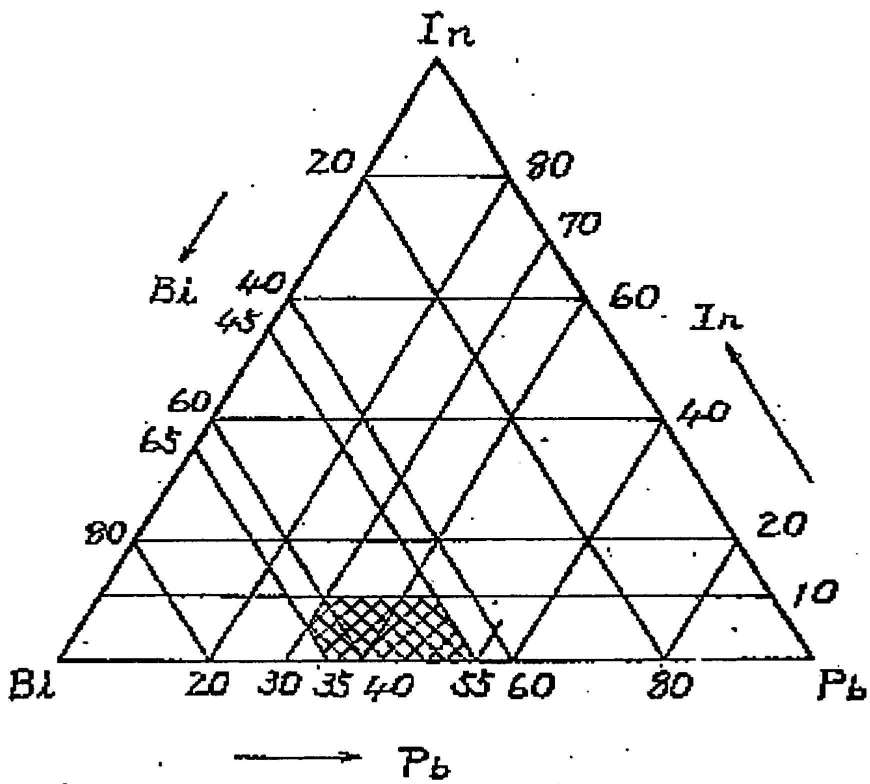

In
20
80
70
Bi
40
45
60
In
60
65
40
80
20
10
Bi
20
30
35
40
55
60
80
Pb
Pb

FIG. 2

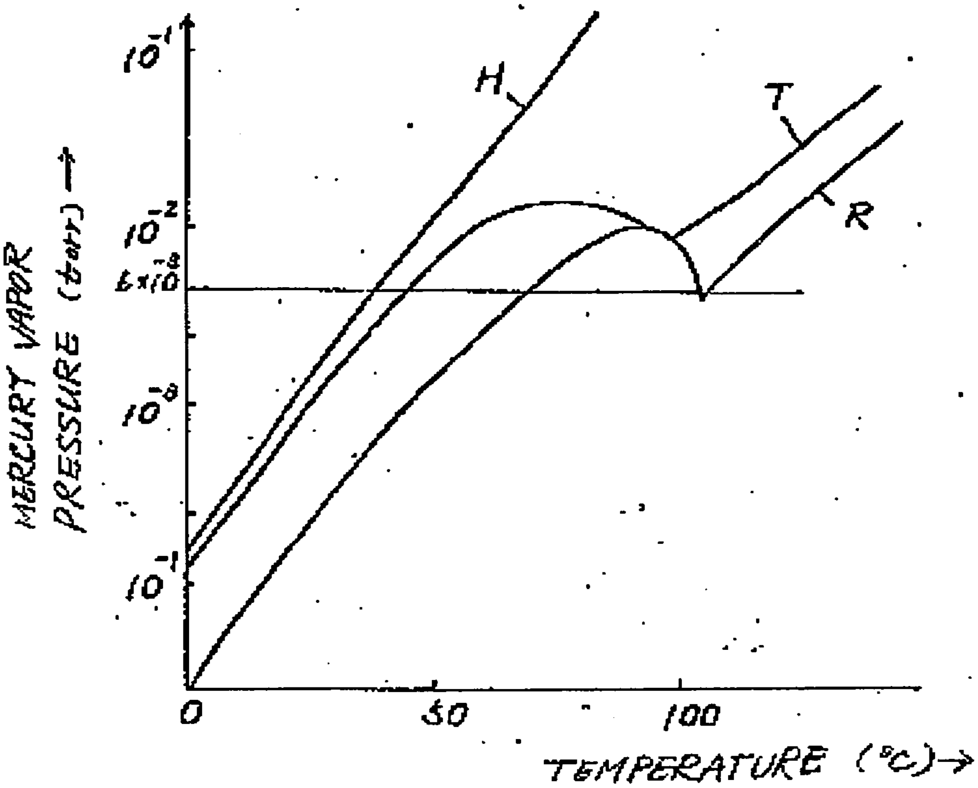

MERCURY VAPOR PRESSURE (torr) →
10^{-1}
10^{-2}
6×10^{-3}
10^{-3}
10^{-4}
H
T
R
0
50
100
TEMPERATURE (°C)→

FIG. 3

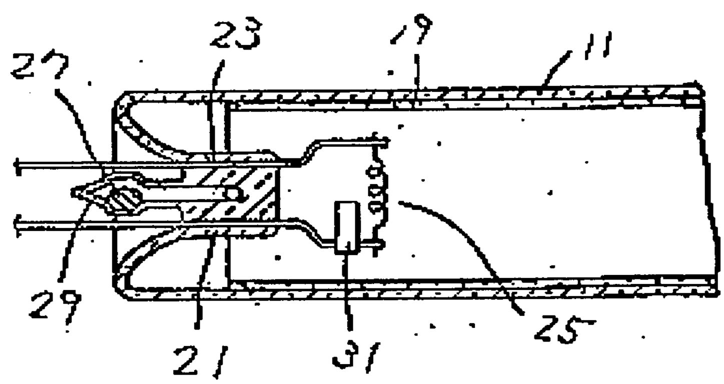

27
23
19
11
29
21
31
25

FIG. 7

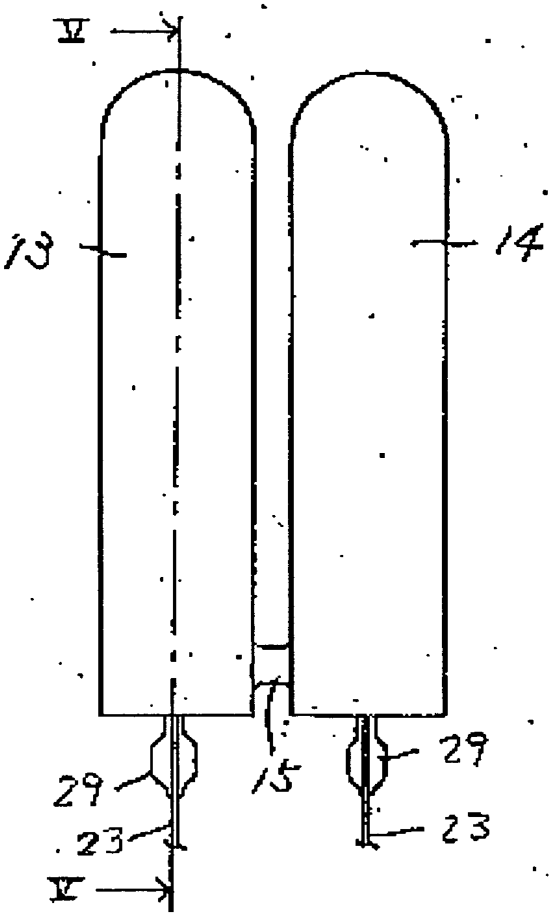


FIG. 4

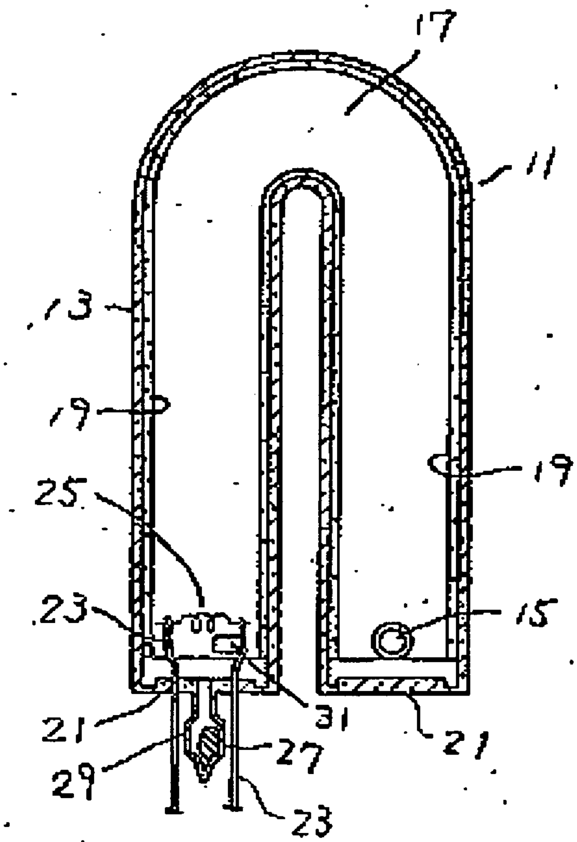


FIG. 5

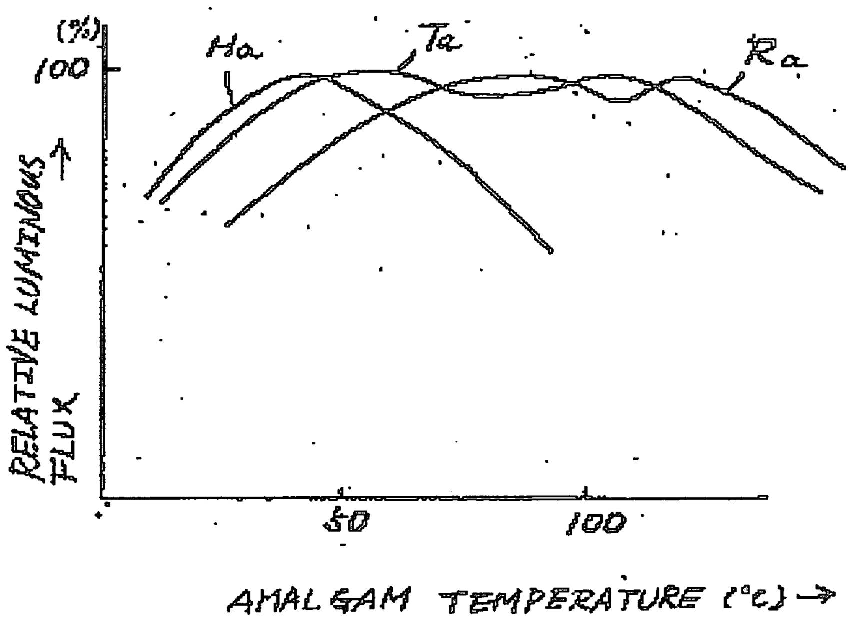

(%)
100
Ha
Ta
Ra
RELATIVE LUMINOUS FLUX ↑
50
100
AMALGAM TEMPERATURE (°C) →

FIG. 6

Europäisches Patentamt
European Patent Office
Office européen des brevets

(19)

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(54) **Amalgam suitable for use in a low mercury vapor pressure discharge lamp.**

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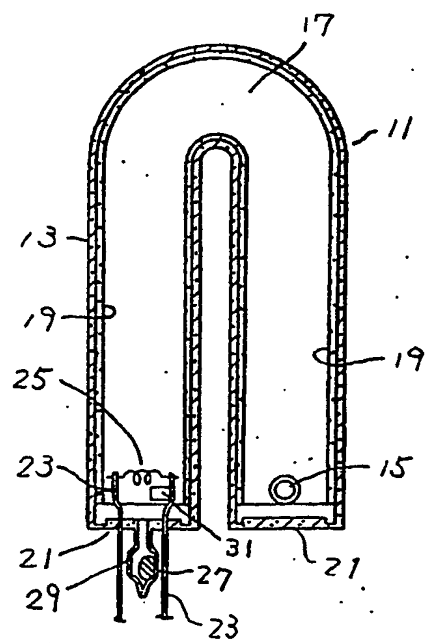

FIG. 5

EP 0 327 346 A3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 89 30 0987

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	FR-A-2 343 329 (N. V. PHILIPS' GLOEILAMPEN-FABRIEKEN) * the whole document *	1-9	H 01 J 61/28
Y	EP-A-0 157 440 (N. V. PHILIPS' GLOEILAMPEN-FABRIEKEN) * abstract; figures 1, 3 * * page 1, line 1 - page 3, line 22 *	1-9	
Y,A	EP-A-0 119 666 (N. V. PHILIPS' GLOEILAMPEN-FABRIEKEN) * abstract; figure * * page 1, paragraph 2 * * page 3, lines 14 - 27 @ page 5, lines 3 - 9 @ page 5, lines 28 - 30 *	1-5,7,6,9	
Y	PATENT ABSTRACTS OF JAPAN vol. 11, no. 254 (E-533) 18 August 1987, & JP-A-62 64044 (MATSUSHITA ELECTRONICS CORP.) 20 March 1987, * the whole document *	1-6,8,9	
A	EP-A-0 136 866 (KABUSHIKI KAISHA TOSHIBA) * page 1, line 1 - page 2, line 16; figure 5 * * page 9, line 30 - page 10, line 29 *	1-3	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

H 01 J
C 22 C

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	19 December 90	MARTIN Y VICENTE M.A

CATEGORY OF CITED DOCUMENTS

X: particularly relevant if taken alone
Y: particularly relevant if combined with another document of the same catagory
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention

E: earlier patent document, but published on, or after the filing date
D: document cited in the application
L: document cited for other reasons

&: member of the same patent family, corresponding document